Industrial Technologies Program

Performance and Value of CAD-Deficient Pine

Performance and value characterization of partially CAD-deficient wood may produce faster growing trees that require less energy for pulping, which will yield higher brightness and paper strength

The southern U.S. produces 58% of the nation's timber and 15.8% of the world's. Much of this timber is genetically improved loblolly pine (Pinus taeda L.) and is produced on short-rotation, intensively managed plantations where the area under management is expected to increase 60% by 2040. One of the fastest-growing loblolly pine selections made by the North Carolina State University (NCSU) Industry Cooperative Tree Improvement Program is also the only known natural carrier of a rare gene, cad-n1. The cad-n1 gene codes for deficiency in the cinnamyl alcohol dehydrogenase (CAD) enzyme, which catalyzes the last step in the biosynthesis of lignin precursors. Although evidence is currently limited on cad-n1 trees, preliminary data indicate that trees carrying a single copy of cad-n1 grow 14% faster and require less energy for pulping, producing higher brightness and paper strength.

Introduction of cad-n1 to forest plantations would result in faster-growing populations that require less energy for pulping and yield increased brightness and paper strength. Large-scale introduction of cad-n1 requires characterization of the rare gene in harvest-age trees in a broad range of environments and in diverse genetic backgrounds. Understanding the genetic components of growth and wood-fiber traits in partially CAD-deficient and normal trees will provide the basis for a strategy to incorporate these traits into the Cooperative breeding program. This research will enhance the sustainability of forest production in the South, where land-use pressures will limit the total area available in the future for intensively managed plantations. This research will also provide information to establish higher-value plantation forests with more desirable wood/fiber quality traits.

Fast-growing loblolly pine plantation.

Benefits

- *14% higher plantation yield*
- *$3 - $8/ODT pulp savings*
- *30% reduction in energy use, costs of harvesting and transportation*
- *Wood processing energy savings*
- *Reduction in harvesting pressure on sensitive area*
- *Over 5% reduction in CO_2 emissions*
- *Over 1% reduction in SO_2, NO_x and other mill emissions*

Applications

Breeding of loblolly pines having the cad-n1 gene could produce superior raw material for the U.S. pulp and paper industry.

Project Description

Goal: Characterize the performance and value of partially CAD-deficient wood, arising from cad-n1 identified in descendants of an exceptionally fast-growing pine.

The specific objectives of this study are:

1. To compare lignin formation in partially CAD-deficient and "normal" trees, ranging in age from 6 years to rotation age in multiple genetic and environmental backgrounds, in both juvenile and mature wood;
2. To identify associations between CAD genotype and growth performance (growth, stem form, and defect in older trees, developmental traits in younger trees);
3. To conduct laboratory studies to confirm the value of partially CAD-deficient wood for energy savings in pulp production and impact on properties of solid-wood products; and
4. To develop approaches to marker-assisted breeding for partially CAD-deficient wood.

Progress and milestones

- The NCSU-Industry Cooperative Tree Improvement Program has been operating for 47 years, and its members are responsible for the genetic improvement of most loblolly pines planted in the South.
- A loblolly pine selected in 1957, is one of the cooperative's best-performing 1st-generation parents. Producing, on average, 30% more volume than commercial check lots, its progenies have been widely planted throughout the South.
- Breeding work based on this parent has produced two types of mutant trees: partially and totally CAD-deficient. Totally CAD-deficient trees have shown to produce wood that is much more easily delignified; however, pulp yields are relatively low in comparison to "normal" pine, and the inbred nature of these trees results in poor growth.
- Preliminary data for 4-year-old descendants from the original cad-n1 ancestor indicate that those carrying a single copy of cad-n1 (partially CAD-deficient) grow 14% faster and require less energy for pulping, producing higher brightness and paper strength.

A Strong Energy Portfolio for a Strong America
Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

Project Partners

North Carolina State University
USDA Forest Service
Southern Institute of Forest Genetics
Université Laval
International Paper Company
MeadWestvaco Corporation
Plum Creek Timber Company
Rayonier Inc.

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